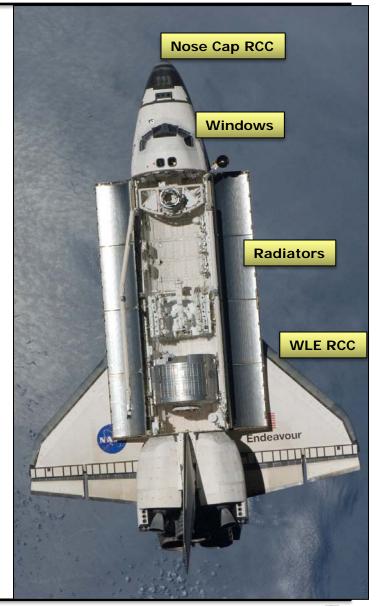


#### Introduction

- 135 shuttle missions between April 1981 & July 2011
- Post flight refurbishment includes micrometeoroid & orbital debris (MMOD) inspection
- Total surface area ≈ 1570 m²
- Regions with detailed MMOD inspections
  - Payload Bay Door Radiators (7.6%)
  - Wing Leading Edge/Nose Cap Reinforced Carbon-Carbon (2.5%)
  - ☐ Crew Module Windows (0.2%)
  - 10.3% of total area

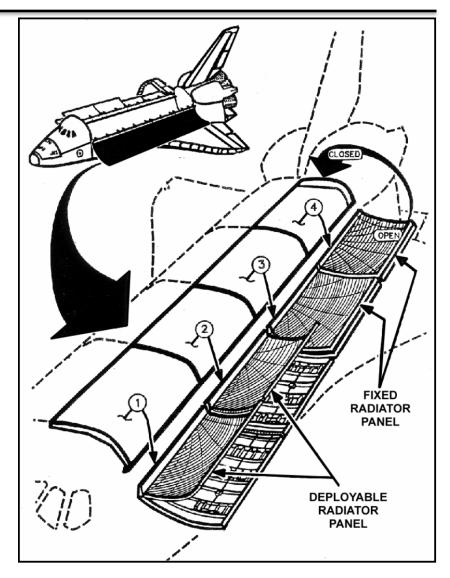






## **Payload Bay Door Radiators**

- Four panels per door
- □ 3.2 x 4.6 m
- □ Area ~120 m²
- Aluminum sandwich panels with silver-Teflon thermal tape
- Open while on orbit (radiators exposed to MMOD environment)
- □ Closed for ascent/entry (radiators protected)





## Payload Bay Door Radiators: Inspection

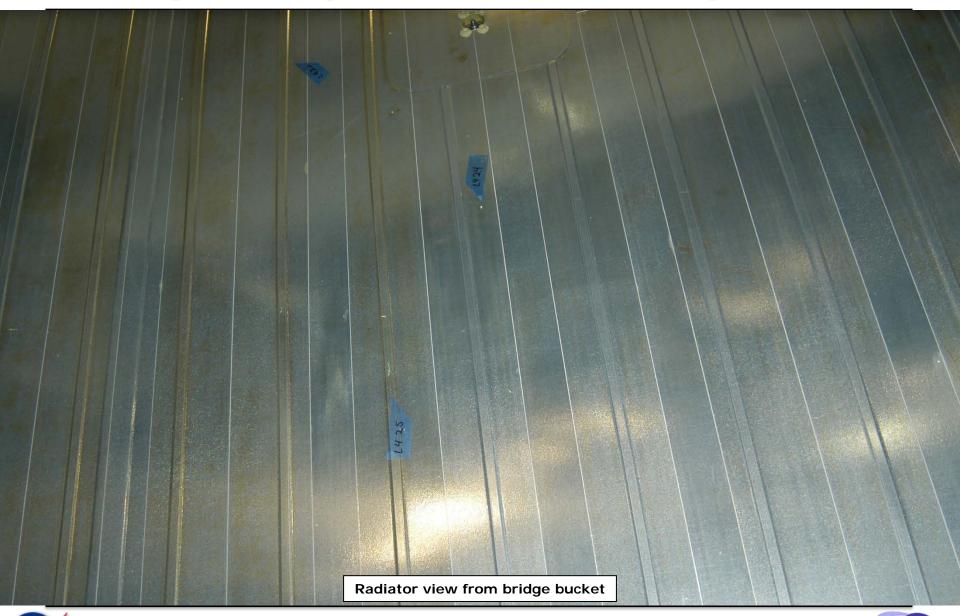
- Radiator dent & ding inspections were performed after each mission using a bridge crane and 2 platforms.
- Required contamination suits







# Payload Bay Door Radiators: Inspection

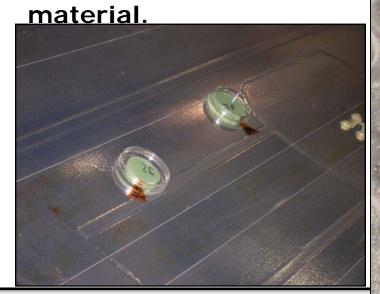


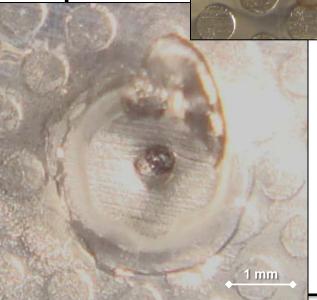


## Payload Bay Door Radiators: Sampling

■ 1 face sheet hole was observed (average) per mission. Thermal tape removed during repair is saved for SEM/EDS analysis. Material around face sheet hole was also recovered.

□ Face sheet craters were the most commonly reported damage feature. Sampling was performed with Reprosil® vinyl polysiloxane impression







# Payload Bay Door Radiators: Sampling

■ Radiator tape damage (tape holes) were reported less frequently than face sheet craters, probably due to observational bias or oversight. Small defects may have been perceived as insignificant and overlooked. Thermal tape removed during repair is saved for SEM/EDS analysis.

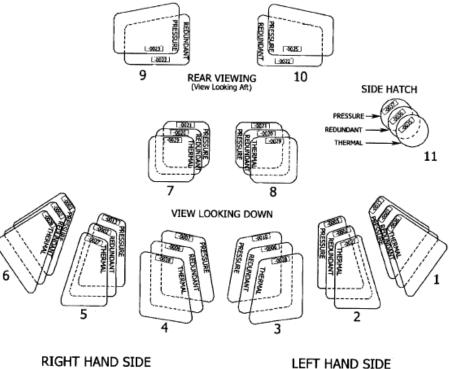




#### **Crew Module Windows**

- 11 windows (~3.6 m² total area)
- Three pane design (Thermal, Redundant, and Pressure)
- Thermal pane material = fused silica





Reference:
Orbiter Window

Inspection Familiarization, May 22, 2006





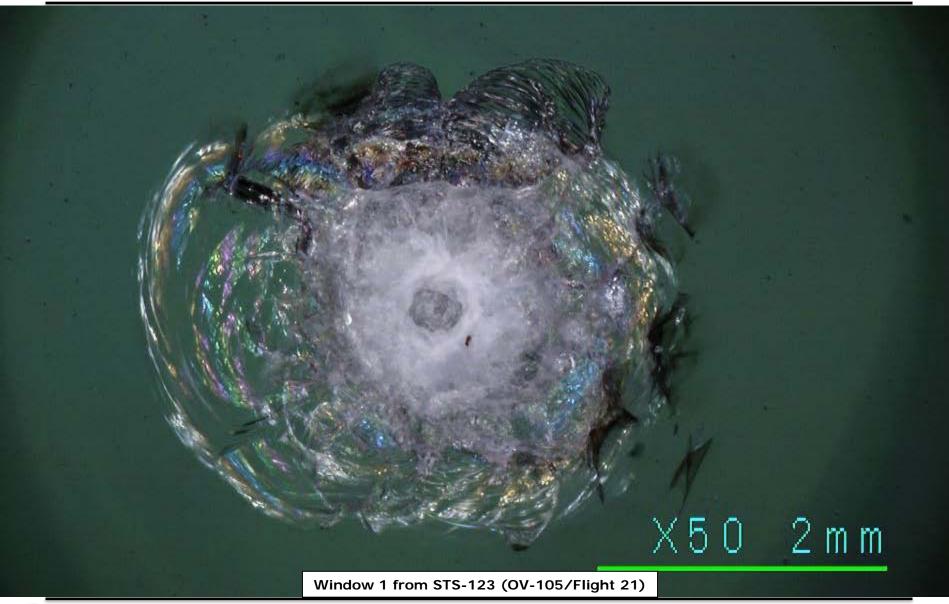
# **Crew Module Windows: Inspection**

Inspection access by platform. Awkward reaches necessary for complete inspection.





## **Crew Module Windows: Inspection**



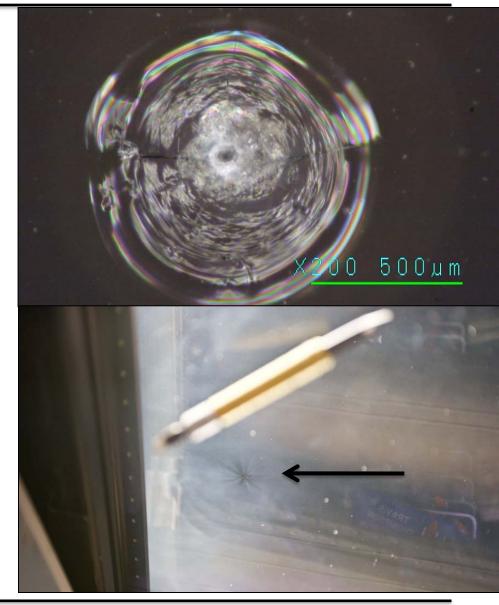




## **Crew Module Windows: Inspection**

Impact features down to 100µm in diameter were easy to detect on the vehicle with clean windows and good lighting.

■ New impacts on W1 and W6 (LH & RH sides) displace plume deposits from Solid Rocket Booster separation motor firings...distinctive radial pattern is easy to see.





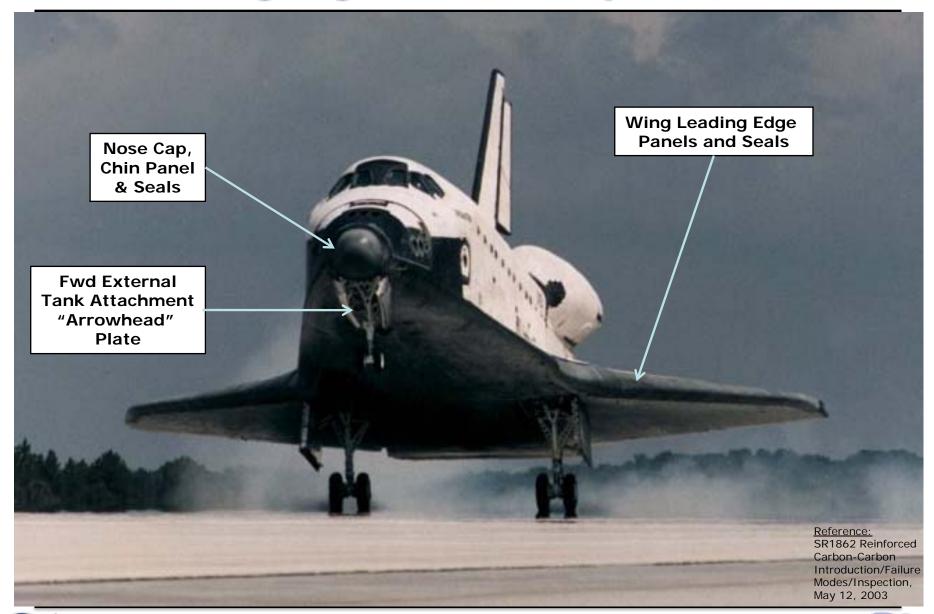
## **Crew Module Windows: Sampling**

Reprosil® vinyl polysiloxane impression material was used on suspected MMOD sites to measure crater features & extract projectile residue. SEM/EDS used to discern the source of impact.





# Leading Edge Structural System/RCC

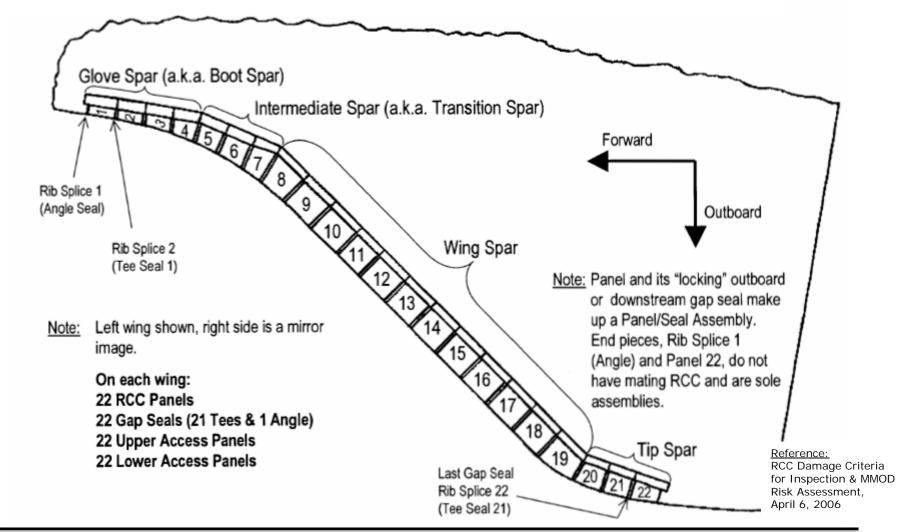






## Leading Edge Structural System/RCC

- Wing Leading Edge Panels
- 22 Panels and Seals per Wing (total area ≈ 35.7 m²)

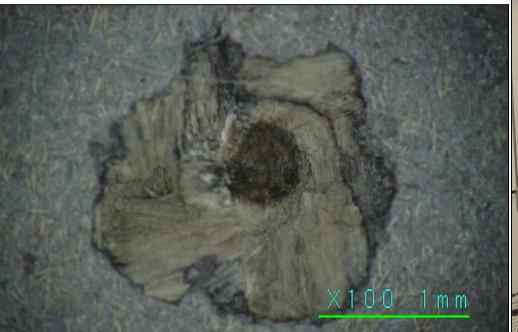






## Leading Edge Structural System/RCC: Inspection

- Inspection access by platform. Overhead reaches necessary for complete inspection.
- MMOD impacts in RCC produce distinctive damage features.



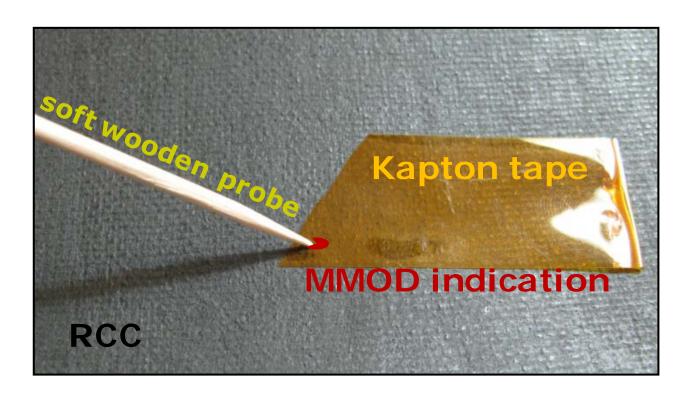






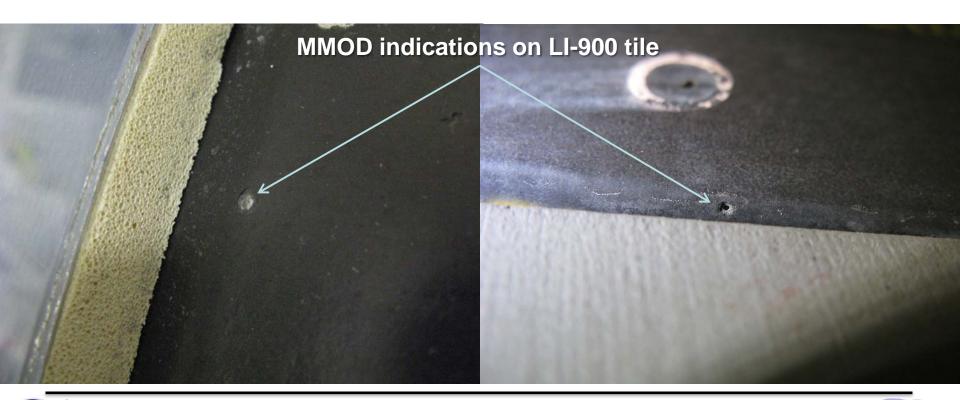
## Leading Edge Structural System/RCC: Sampling

Suspected MMOD impact sites were sampled with a tape pull technique. Projectile residue on tape was analyzed with SEM/EDS to discern the source.



# **Thermal Protection System (TPS) Tiles**

- Hypervelocity impact features in LI-900 TPS tend to have internal cavities that are larger than the entry hole.
- Difficult to sample on the vehicle. In a few instances scrapped tiles were removed and MMOD damage sites cored for direct analysis in the SEM/EDS







## **Thruster Nozzles: Reaction Control System**

- Crater in C103 Niobium alloy
- Distinctive coating loss and central crater





## Thruster Nozzles: Orbital Maneuvering System

Impact in OMS main engine nozzle (entry crater) 1.2 mm crater diameter 0.6 mm estimated crater depth ~70% of 0.86 mm (0.034 in)5.2 mm nominal wall thickness 4.7 mm



## Thruster Nozzles: Orbital Maneuvering System

Impact in OMS main engine nozzle (back side damage)





## **Database Overview: Home Page**

#### **Shuttle Hypervelocity Impact Database - Home**

#### **Crew Module Windows**

Number of Records - 1894

Window Impact Data

**Window Impact Stats** 

Window Replacement Data

Replacements per Mission

Replacements per Mission-Day

**Replacement History** 

Payload Bay Door Radiators

Number of Records - 604

**Radiator Impact Data** 

**Radiator Impact Stats** 

**Facesheet Perforation Data** 

**Facesheet Perforations** 

Facesheet Perfs per Mission-Day

**RCC, FRSI & other areas** 

Number of Records - 453

**Impact Data** 

**Database Curator:** 

Jim Hyde 281-244-5068

**Last Update:** 

24-Aug-2011

**Change Log** 





# **Crew Module Window Summary**

Distinct Missions: 89 missions with window impacts
Total Missions: 133 (STS-1 thru STS-133)

#### Total DB Records = 1894

Impact Sources										
Unknown*	1315	69%								
Micrometeoroids (MM)	262	14%								
Orbital Debris (OD)	317	17%								
Total 1894										

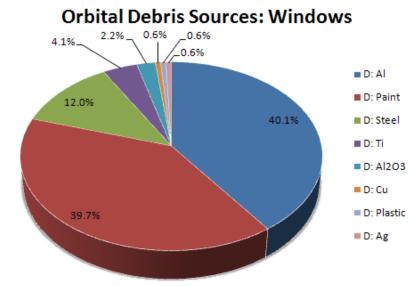
unknown assumed to be meteoroids

Damage Feature Size												
Feature	AVG (mm)	MAX (mm)	MIN (mm)									
Crater Length	0.480	13.434	0.050									
Crater Width	0.429	8.966	0.036									
Crater Depth	0.050	0.828	0.011									

Estimated Projectile Sizes												
Damage Feature	AVG (mm)	MAX (mm)	MIN (mm)									
Crack/Flaw Diameter	0.028	0.309	0.0057									
Crater Depth	0.023	0.406	0.0052									

Replacements (thru STS-133)											
total replacements (MMOD)	183										
replacements/mission	1.35										
replacements/mission-day	0.14										

OD Sources												
D: Al	127											
D: Paint	126											
D: Steel	38											
D: Ti	13											
D: Al2O3	7											
D: Cu	2											
D: Plastic	2											
D: Ag	2											
D: Na/K	0											
D: binders	0											
D: waste	0											
D: NiCd	0											
D: PCboard	0											
Total 317												



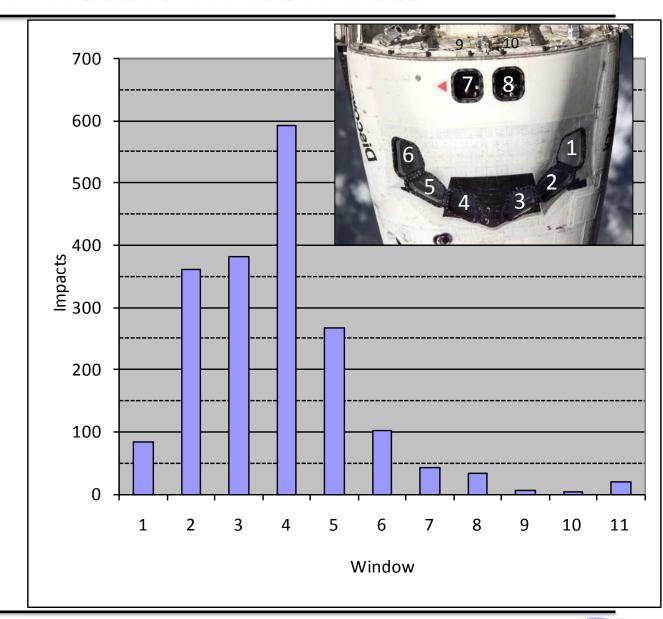


	CREW MODULE WINDOWS - HYPERVELOCITY IMPACT DATA																	
Home	THE STATE OF THE S																	
	Window	Pane Scrapped	PR	Crater Dimension	ns (mm)	Estimated In	pactor (mm)	SEM Particle	Assessed Particle		Particle Density	Impact Velocity			Dental Mold	JSC	KSC	
STS 🔻	Number 🔻	? 🔻	T.	Length Width			Length *	Type 🔻	Type 🔻	SEM/EDXA Results	(g/cm³) ▼	(km/s) ▼	(deg)	Crater Diam (mm) 🔻	sample? ▼	source 🔻	EICN 🔻	Comments
119	6	Υ	-		х	0.03	Length	D	D: Ti	OD: Fe-Ti alloy?	4.5	7.14	45	0.65	Sample	JSC-64986	none	crater dim estimated from JSC DG3 image
119	6	Υ	3		x 0.015	0.01	0.01	U	М	no sample	1.0	23.0	45	0.14		JSC-64986	TES-3-37-1122	crater dim estimated from KSC/MIT
119	6	Υ	4		x 0.024	0.02	0.01	U	M	no sample	1.0	23.0	45	0.28		JSC-64986	TES-3-37-1122	crater dim estimated from KSC/MIT
119	7	Y	3		x 0.036	0.03	0.02	U	M	indeterminte: (Fe)	1.0	23.0	45	0.42		JSC-64986	TES-3-37-1121	crater dim estimated from KSC/MIT
119 119	7	Y	5		x 0.051 x 0.046	0.03	0.03	D U	D: Paint M	OD: paint (Ti) no sample	2.5 1.0	7.14 23.0	45 45	0.48		JSC-64986 JSC-64986	TES-3-37-1121 TES-3-37-1121	crater dim estimated from KSC/MIT
119	7	Y	6		x 0.019	0.01	0.02	U	M	no sample	1.0	23.0	45	0.15		JSC-64986	TES-3-37-1121	crater dim estimated from KSC/MIT
119	10		1		x 0.053	0.05	0.02	U	M	no sample	1.0	23.0	45	0.94		JSC-64986	TES-3-37-1129	crater dim estimated from KSC/MIT
125	1	Y		0.163 x 0.119	x 0.017	0.01	0.01	U	M	Unknown	1.0	23.0	45	0.14		JSC-64963	TES-4-31-0938	crater dim estimated from KSC/MIT
125	1	Υ			x 0.038	0.02	0.02	U	M	Unknown	1.0	23.0	45	0.24		JSC-64963	TES-4-31-0938	crater dim estimated from KSC/MIT
125	4			21220 11 21022	x 0.218	0.07	0.09	U	M	Unknown Unknown	1.0	23.0	45	1.43		JSC-64963 JSC-64963	TES-4-31-0937 TES-4-31-0935	crater dim estimated from KSC/MIT
125 127	1	Y	2		x 0.020 x 0.310	0.02	0.01 0.16	D	D: Paint	OD: paint (Fe, Ti, Si)	1.0 2.5	23.0 7.15	45 45	0.20 2.11	Υ	JSC-64963 JSC-64938	TES-5-24-0727	crater dim estimated from KSC/MIT crater dim estimated from KSC/MIT
127	1	Y	3		x 0.130	0.05	0.05	U	M	not analyzed	1.0	23.0	45	0.91		JSC-64938	TES-5-24-0727	crater dim estimated from KSC/MIT
127	2		1		x 0.066	0.02	0.03	U	M	Unknown (no MMOD indication)	1.0	23.0	45	0.20		JSC-64938	TES-5-24-0731	crater dim estimated from KSC/MIT
127	2		2		x 0.061	0.03	0.03	U	M	no sample	1.0	23.0	45	0.43		JSC-64938	TES-5-24-0731	crater dim estimated from KSC/MIT
127	3		-	0.403 x 0.378	x 0.011	0.03	0.01	U	M	not analyzed	1.0	23.0	45	0.39		JSC-64938	none	crater dim estimated from JSC DG3 image
127	4		1	0.662 x 0.648	x 0.058	0.04	0.03	U	M	not analyzed	1.0	23.0	45	0.65		JSC-64938	TES-5-24-0730	crater dim estimated from KSC/MIT
127 127	6	Y	2	0.305 x 0.290 0.391 x 0.376	x 0.030 x 0.036	0.02	0.01	U	M	no sample no sample	1.0	23.0 23.0	45 45	0.30		JSC-64938 JSC-64938	TES-5-24-0729 TES-5-24-0729	crater dim estimated from KSC/MIT crater dim estimated from KSC/MIT
127	6	V	3	0.386 x 0.386		0.03	0.02	U	M	not analyzed	1.0	23.0	45	0.39		JSC-64938	TES-5-24-0729	crater dim estimated from KSC/MIT
127	6	Y	6	0.163 x 0.109		0.01	0.01	U	M	no sample	1.0	23.0	45	0.14		JSC-64938	TES-5-24-0729	crater dim estimated from KSC/MIT
127	6	Υ	8	0.742 x 0.681		0.04	0.03	U	M	not analyzed	1.0	23.0	45	0.71		JSC-64938	TES-5-24-0729	crater dim estimated from KSC/MIT
127	6	Υ	9	0.965 x 0.942		0.05	0.03	U	M	not analyzed	1.0	23.0	45	0.95		JSC-64938	TES-5-24-0729	crater dim estimated from KSC/MIT
127	6	Y	10		x 0.112	0.05	0.05	U	M	no sample	1.0	23.0	45	0.84		JSC-64938	TES-5-24-0729	crater dim estimated from KSC/MIT
127	7	Υ	1		x 0.107	0.04	0.04	U	М	not analyzed	1.0	23.0	45	0.66		JSC-64938	TES-5-24-0732	crater dim estimated from KSC/MIT
127 127	8	Y	3	1.448 x 1.143 0.711 x 0.584	x 0.109 x 0.064	0.07	0.05	U	M	unknown (Fe, Ti, S, NaCl, BaSO4) Unknown	1.0	23.0 23.0	45 45	1.30 0.65		JSC-64938 JSC-64938	TES-5-24-0728 TES-5-24-0728	crater dim estimated from KSC/MIT
127	1	Y	2		x 0.064 x 0.246	0.04	0.03	D	D: Ti	OD: Fe.Ti.Sr.Cr.Pb	4.5	7.15	45	3.05		JSC-64958 JSC-64969	TES-3-38-1132	crater dim estimated from KSC/MIT
128	2		4		x 0.052	0.03	0.02	Ü	M	not analyzed	1.0	23.0	45	0.51		JSC-64969	TES-3-38-1136	crater dim estimated from KSC/MIT
128	3		6		x 0.089	0.05	0.04	U	M	not analyzed	1.0	23.0	45	1.03		JSC-64969	TES-3-38-1133	crater dim estimated from KSC/MIT
128	3		7		x 0.081	0.05	0.03	U	M	not analyzed	1.0	23.0	45	0.85		JSC-64969	TES-3-38-1133	crater dim estimated from KSC/MIT
128	4		10		x 0.160	0.06	0.08	D	D: Al	OD: Al, MgSiO, Sb, Zr, Ti, Fe	2.8	7.15	45	1.11		JSC-64969	TES-3-38-1135	crater dim estimated from KSC/MIT
128	5		1		x 0.085	0.06	0.05	D	D: Paint	OD: Ti, Fe, Zn, Zr, W	2.5	7.15	45	1.13		JSC-64969	TES-3-38-1137	crater dim estimated from KSC/MIT
128 128	6	Y	2		x 0.058 x 0.089	0.04	0.03	U	M	not analyzed not analyzed	1.0	23.0 23.0	45 45	0.65 0.85		JSC-64969 JSC-64969	TES-3-38-1131 TES-3-38-1131	crater dim estimated from KSC/MIT crater dim estimated from KSC/MIT
128	6	Y	3	0.274 x 0.208	x 0.033	0.03	0.01	U	M	no sample	1.0	23.0	45	0.24		JSC-64969	TES-3-38-1131	crater dim estimated from KSC/MIT
128	6	Υ	4	0.267 x 0.234	x 0.020	0.02	0.01	U	M	no sample	1.0	23.0	45	0.25		JSC-64969	TES-3-38-1131	crater dim estimated from KSC/MIT
128	7		1	0.353 x 0.236	x 0.036	0.02	0.02	U	M	not analyzed	1.0	23.0	45	0.29		JSC-64969	TES-3-38-1134	crater dim estimated from KSC/MIT
129	1	Υ	1		x 0.112	0.06	0.05	U	M	unknown (Ti)	1.0	23.0	45	1.22		JSC-65758	TES-4-32-0969	crater dim estimated from KSC/MIT
129	1	Υ	2		x 0.056	0.03	0.02	U	М	unknown (Fe)	1.0	23.0	45	0.52		JSC-65758	TES-4-32-0969	crater dim estimated from KSC/MIT
129 129	1	Y	3		x 0.051 x 0.036	0.02	0.02	D U	D: Ti M	OD (Ti) no sample	4.5 1.0	7.15 23.0	45 45	0.36 0.35		JSC-65758 JSC-65758	TES-4-32-0969 TES-4-32-0969	crater dim estimated from KSC/MIT crater dim estimated from KSC/MIT
129	1	Y	6		x 0.036	0.02	0.02	U	M	no sample	1.0	23.0	45	0.35		JSC-65758 JSC-65758	TES-4-32-0969	crater dim estimated from KSC/MIT
129	3		3		x 0.066	0.06	0.03	U	M	Unknown	1.0	23.0	45	1.10		JSC-65758	TES-4-32-0967	crater dim estimated from KSC/MIT
129	3		4		x 0.058	0.02	0.03	U	М	Unknown	1.0	23.0	45	0.34		JSC-65758	TES-4-32-0967	crater dim estimated from KSC/MIT
129	4		2		x 0.058	0.03	0.03	U	М	no sample	1.0	23.0	45	0.39		JSC-65758	TES-4-32-0966	crater dim estimated from KSC/MIT
129	4		3		x 0.086	0.05	0.04	U	M	Unknown	1.0	23.0	45	0.84		JSC-65758	TES-4-32-0966	crater dim estimated from KSC/MIT
129	6	Y	1		x 0.052	0.04	0.02	U	M	no sample	1.0	23.0	45	0.66		JSC-65758	TES-4-32-0964	crater dim estimated from KSC/MIT
129 129	6	Y	3		x 0.015 x 0.020	0.01	0.01	U	M	no sample	1.0	23.0 23.0	45 45	0.12 0.14		JSC-65758 JSC-65758	TES-4-32-0964 TES-4-32-0964	crater dim estimated from KSC/MIT crater dim estimated from KSC/MIT
129	8	Y	1		x 0.020	0.01	0.01	D	D: Paint	OD (Ti, Fe, Zn, Pb)	2.5	7.15	45	0.14		JSC-65758	TES-4-32-0965	crater dim estimated from KSC/MIT
130	1	Y	1		x 0.262	0.15	0.10	U	М	unknown: Si	1.0	23.0	45	3.97		JSC-65826	TES-5-25-0740	crater dim estimated from KSC/MIT
130	1	Υ	2		x 0.033	0.03	0.01	U	М	no sample	1.0	23.0	45	0.38		JSC-65826	TES-5-25-0740	crater dim estimated from KSC/MIT
130	1	Y	3	0.100 X 0.170	x 0.041	0.03	0.02	U	М	no sample	1.0	23.0	45	0.48		JSC-65826	TES-5-25-0740	crater dim estimated from KSC/MIT
130	1	Y	4		x 0.018	0.01	0.01	U	M	no sample	1.0	23.0	45	0.13		JSC-65826	TES-5-25-0740	crater dim estimated from KSC/MIT
130 130	1	Y	5	0.221 x 0.147 0.472 x 0.389	x 0.023 x 0.064	0.02	0.01	U D	D:Ti	no sample OD: Fe. Ti	1.0 4.5	23.0 7.15	45 45	0.18 0.43		JSC-65826 JSC-65826	TES-5-25-0740 TES-5-25-0744	crater dim estimated from KSC/MIT
130	2	Y	5		x 0.064 x 0.094	0.03	0.03	U	M M	no sample	1.0	23.0	45	0.43		JSC-65826 JSC-65826	TES-5-25-0744	crater dim estimated from KSC/MIT
130	2	Y	6		x 0.198	0.07	0.08	Ü	M	unknown: Si	1.0	23.0	45	1.43		JSC-65826	TES-5-25-0744	crater dim estimated from KSC/MIT
130	2	Υ	_		x	0.02		D	D: Steel	OD: Fe	7.9	7.15	45	0.39		JSC-65826	none	crater dim estimated from JSC DG3 image
130	3		5	0.965 x 0.864		0.05	0.04	U	М	not analyzed	1.0	23.0	45	0.91		JSC-65826	TES-5-25-0743	crater dim estimated from KSC/MIT
130	3		6	0.559 x 0.533		0.03	0.05	U	М	not analyzed	1.0	23.0	45	0.55		JSC-65826	TES-5-25-0743	crater dim estimated from KSC/MIT
130	4		6	0.439 x 0.373		0.03	0.03	U	M	no sample	1.0	23.0	45	0.41		JSC-65826	TES-5-25-0742	crater dim estimated from KSC/MIT
130	4			0.130 x 0.117	X	0.01		U	M	unable to determine	1.0	23.0	45	0.12		JSC-65826	none	crater dim estimated from JSC DG3 image



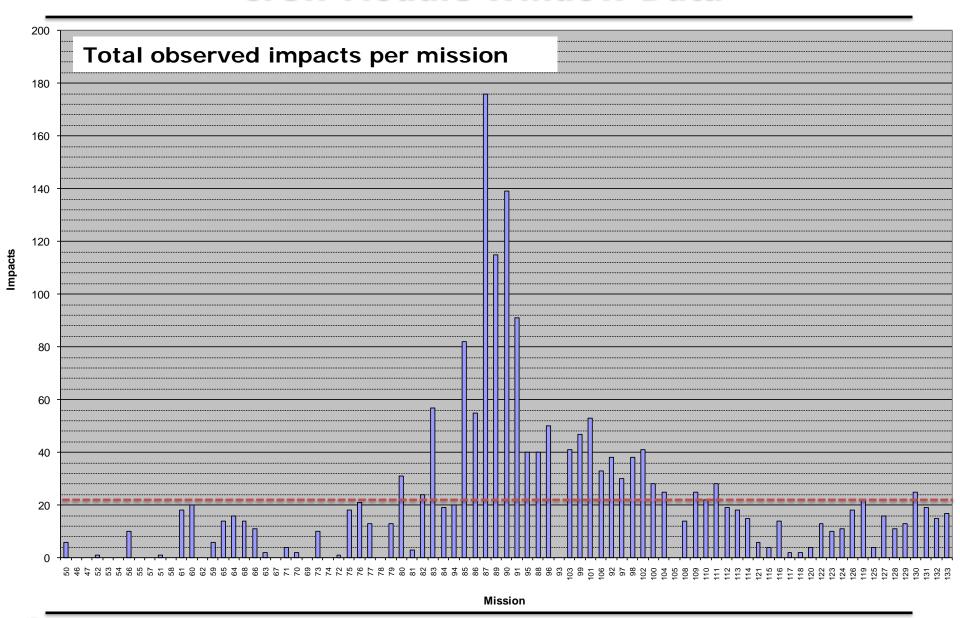


- Total observed impacts per window.
- Distribution at W4 was skewed by a large number of impacts on STS-85 thru STS-91.



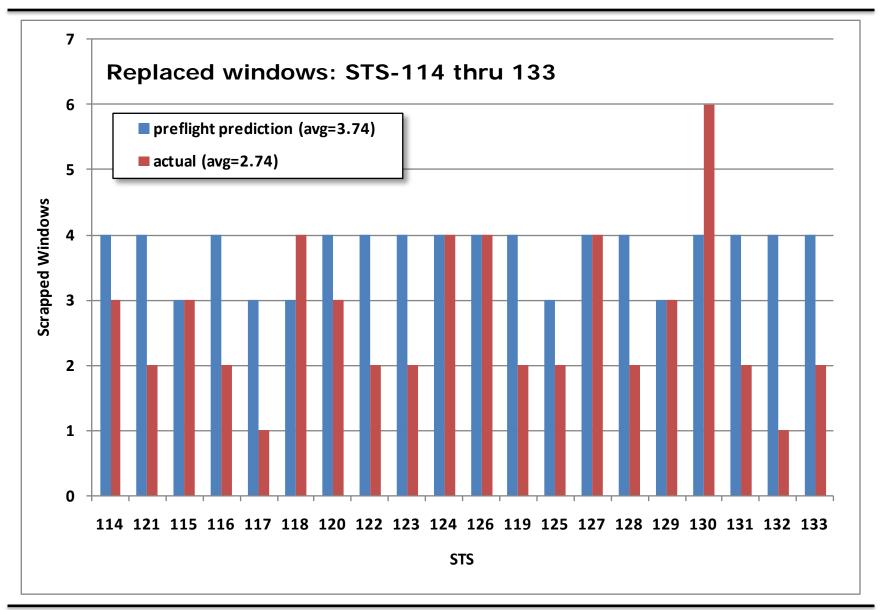
















## **Payload Bay Door Radiator Summary**

Distinct Missions: 73 missions with radiator impacts

Total Missions: 133 (STS-1 thru STS-133)

Total DB Records = 601

Tape Holes = 137
Facesheet Craters = 388
Facesheet Holes = 76

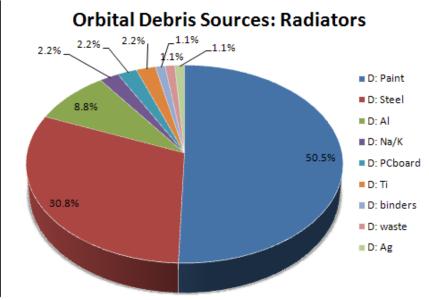
Impact Sources		
Unknown*	427	71%
Micrometeoroids (MM)	83	14%
Orbital Debris (OD)	91	15%
Total	601	

<sup>\*</sup> unknowns were assumed to be 60% meteoroids & 40% aluminum

Damage Feature Size			
Feature	AVG (mm)	MAX (mm)	MIN (mm)
Tape Hole Diameter	1.90	8.30	0.203
Face Sheet Crater Diameter	0.82	10.57	0.020
Face Sheet Crater Depth	0.11	2.40	0.003
Face Sheet Hole Diameter	1.02	5.54	0.025

Estimated Projectile Sizes												
Damage Feature	AVG (mm)	MAX (mm)	MIN (mm)									
Tape Hole	0.25	1.79	0.024									
Face Sheet Crater	0.12	1.03	0.053									
Face Sheet Hole	0.26	3.84	0.001									

OD Sources											
D: Paint	46										
D: Steel	28										
D: Al	8										
D: Na/K	2										
D: PCboard	2										
D: Ti	2										
D: binders	1										
D: waste	1										
D: Ag	1										
D: Al2O3	0										
D: Cu	0										
D: NiCd	0										
D: Plastic	0										
Total	91										





# **Payload Bay Door Radiator Data**

	PAYLOAD BAY DOOR RADIATORS - HYPERVELOCITY IMPACT DATA																		
<u>Home</u>									P/	AYLOAD	BAY DOO	R RADIAT	ORS - HYF	ERVELOC	ITY IMPAG	T DATA			
											Estimate	ed Impactor [	Diameter						
				Tape I			_				Tape Hole	Face Sheet	Face Sheet	SEM	Assessed		Particle	Impact	
CTC ▼		Sample #			er (mm)		Faces	heet Damag	(mm)		Diam	Crater Depth	Hole Diam	Particle	Particle	SEM/EDXA Results	Density	Velocity	Notes -
STS ▼ 119	Panel ▼ LH1		lengt		width ▼	length 0.19		0.17		depth ▼ 0.02	(mm) *	(mm) *	(mm) 🔻	Type ▼	Type ▼ D: Al	Serie Contraction	(g/cm³) ▼ 2.8	(km/s) ▼ 7.14	Notes ▼ DR STR-3-37-9770
119	LH1 LH1	19 20		X		0.19	X	0.17	×	0.02		0.08		U	D: Al	Unknown Unknown	2.8	7.14	STR-3-37-9770
119	LH1	21		×		0.51	×	0.51	×	hole			0.04	D	D: steel	Fe, Ti, Fe-Cr-Ni	7.9	7.14	STR-3-37-9770
119	LH1	22		×	_	0.75	X	0.70	×	0.09	_	0.11		U	M	Unknown	1.0	23.00	STR-3-37-9770
119	LH1	23		X	_	0.20	X	0.19	X	0.10		0.11	_	U	M	Unknown	1.0	23.00	STR-3-37-9770
119	LH1	24	0.63	×	0.62		х		×		0.08			U	M	Unknown	1.0	23.00	STR-3-37-9770
119	LH2	20	0.56	×	0.57		x	_	x		0.07			U	M	Unknown	1.0	23.00	DR STR-3-37-9771
119	LH3	27		x		0.40	х	0.37	x	0.08		0.10		U	M	Unknown	1.0	23.00	DR STR-3-37-9772
119	LH3	28	0.54	X	0.54	-	Х	-	X		0.07	-	_	U	D: Al	Unknown	2.8	7.14	DR STR-3-31-9772
119	LH4	20	-	X		0.15	Х	0.14	X	0.04		0.07	_	U	M	Unknown	1.0	23.00	DR STR-3-37-9773
119	LH4	21	0.55	X	0.54		Х		X		0.07		_	U	M	Unknown	1.0	23.00	DR STR-3-37-9773
119	RH1	14	-	X		0.64	X	0.57	X	0.25		0.20	_	U	D: Al	Unknown	2.8	7.14	STR-3-37-9766
119	RH1 RH1	15 16	_	X		0.61 0.31	X	0.56	X	0.76		0.45		U	D: Al M	Unknown Unknown	2.8 1.0	7.14 23.00	STR-3-37-9766
119 119	RH1	18		×		0.16	×	0.15	×	0.03		0.08		U	M	Unknown	1.0	23.00	STR-3-37-9766 STR-3-37-9798
119	RH2	14		×		0.47	×	0.13	×	0.02		0.10		U	M	Unknown	1.0	23.00	STR-3-37-9767
119	RH2	15		X		0.36	X	0.35	X	0.05		0.08	_	U	M	Unknown	1.0	23.00	STR-3-37-9767
119	RH3	24	_	×	_	0.43	X	0.43	×	0.06		0.10	_	Ü	D: Al	Unknown	2.8	7.14	STR-3-37-9768
119	RH3	25		×		0.63	×	0.64	x	0.11		0.11	_	U	M	Unknown	1.0	23.00	STR-3-37-9768
119	RH4	19	_	×		0.35	×	0.31	x	0.06		0.08	_	U	M	Unknown	1.0	23.00	STR-3-37-9769
125	LH1	34		x		2.51	x	2.29	x	0.05		0.14		U	D: Al	Unknown	2.8	3.85	STR 4-31-8240
125	LH1	35		x		1.88	x	1.55	x	0.10		0.19		U	D: Al	Unknown	2.8	3.85	STR 4-31-8240
125	LH2	27		x		2.57	x	2.46	x	0.08		0.10		U	M	Unknown	1.0	23.00	STR 4-31-8201
125	LH2	28	-	x		3.86	X	2.36	X	0.13		0.12		U	M	Unknown	1.0	23.00	STR 4-31-8201
125	LH3	32	-	X		1.07	X	0.81	X	0.08		0.18		U	D: Al	Unknown	2.8	3.85	STR 4-31-8241
125	LH3	33	1.68	X	1.04		X		X		0.16			U	M	Unknown	1.0	23.00	STR 4-31-8241
125	LH3	34		X		2.46	х	2.41	X	0.10		0.11		U	M	Unknown	1.0	23.00	STR 4-31-8241
125 125	LH4 LH4	29 30		X		2.39 1.65	X	1.70 1.70	x	0.10		0.19		U	D: Al M	Unknown	2.8 1.0	3.85 23.00	STR 4-31-8242 STR 4-31-8242
125	RH2	24		×		0.64	X	0.64	X	hole		0.10	0.00	U	M	Unknown	1.0	23.00	STR-4-31-8205
125	RH3	33		×		1.02	×	1.02	X	hole	_		0.01	U	M	Unknown	1.0	23.00	STR-4-31-8204
125	RH4	31		x	_	0.48	x	0.69	x	0.15	_	0.22		U	D: Al	Unknown	2.8	3.85	STR-4-31-8202
127	LH1	28	_	×		0.53	x	0.53	X	0.08		0.10	_	U	M	Unknown	1.0	23.00	STR-5-24-5947
127	LH1	30	1.91	×	0.74		х		x		0.16	_	_	U	M	Unknown	1.0	23.00	STR-5-24-5947
127	LH4	18	3.07	×	3.10		x		x		0.41			U	D: Al	Unknown	2.8	7.15	STR-5-24-5949
127	LH4	20	1.09	×	0.99		x	-	x		0.14			U	D: Al	Unknown	2.8	7.15	STR-5-24-5949
127	RH2	18		×		0.28	×	0.25	x	0.03		0.08		U	D: Al	Unknown	2.8	7.15	STR-5-24-5945
127	RH2	19	_	×		0.25	×	0.30	X	0.03		0.06		U	M	Unknown	1.0	23.00	STR-5-24-5946
127	RH3	16	-	X	-	0.86	х	0.89	X	hole			0.16	D	D: paint	Fe,Cu, F,Ti,sm Al spheres	2.5	7.15	STR-5-24-5943
127	RH3	17		X		0.41	Х	0.36	X	0.05		0.08		U	M	Unknown	1.0	23.00	STR-5-24-5944
127	RH4	45	-	×		0.33	X	0.33	×	0.05		0.10		U	D: Al M	Unknown	2.8	7.15	STR-5-24-5942
127 127	RH4 RH4	46 47		X		0.25	X	0.30	X	0.03		0.06		U	M	Unknown	1.0	23.00 23.00	STR-5-24-5942 STR-5-24-5942
127	RH4	48		×		0.38	×	0.36	×	0.15		0.12		U	D: Al	Unknown	2.8	7.15	STR-5-24-5942
128	LH1	25		×		0.90	×	0.86	×	0.20		0.14		U	M	Unknown (Si,Ag,Cr,Ni,Sr)	1.0	23.00	STR-3-38-9837
128	LH2	21		×	_	0.51	×	0.51	x	hole			0.04	U	D: Al	Unknown	2.8	7.15	STR-3-38-9838
128	LH4	22		X		1.02	X	1.02	x	hole			0.23	D	D: paint	Cr, Fe, Ti	2.5	7.15	Str-3-38-9840
128	LH4	25		X		0.48	X	0.48	X	0.02		0.07		U	M	Unknown	1.0	23.00	Str-3-38-9839
128	LH4	26		×	_	0.46	x	0.46	×	0.02	-	0.12	_	U	D: Al	Unknown	2.8	7.15	Str-3-38-9839
128	LH4	27	2.54	×	2.54		x		×		0.33			U	D: Al	Unknown	2.8	7.15	Str-3-38-9839
128	LH4	28		×		0.58	x	0.58	x	0.07		0.09	-	U	М	Unknown	1.0	23.00	Str-3-38-9839
128	RH1	19		×		0.50	x	0.56	×	0.37		0.26		D	D: Al	Al,Si, trace Fe, Cu	2.8	7.15	STR-3-38-9841
128	RH2	16		×	-	0.47	х	0.51	x	0.13		0.12	-	U	M	Unknown	1.0	23.00	STR-3-38-9842
128	RH3	26		×		0.91	X	0.91	×	0.11		0.11	-	U	M	Unknown	1.0	23.00	STR-3-38-9867
128	RH3	30		X		0.60	X	0.56	X	0.11	-	0.14	_	U	D: Al	Unknown	2.8	7.15	STR-3-38-9847
128	RH4	20	0.44	X	0.41		X		X		0.06		-	U	D: Al	Unknown	2.8	7.15	None





## **Summary & Forward Work**

- Excel based list of shuttle inspection results
  - Crew Module Windows
  - Payload Bay Door Radiators
  - Thermal Protection System
- SEM/EDS results included
- Estimated particle diameters
- Forward Work
  - Conversion to web based application
  - Integration with image database
- Additional Datasets
  - ISS returned hardware dataset
  - HST WFPC2 radiator inspection





